THE ECOLOGY OF SUGARLOAF BUSH, CASS

III. SEASONAL PATTERN OF SHOOT EXTENSION AND DIAMETER INCREMENT IN *NOTHOFAGUS SOLANDRI* TREES

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ABSTRACT

The seasonal pattern of shoot extension and diameter increment in *Nothofagus solandri* trees is described. Shoot growth commenced before diameter growth and lasted about three months. Diameter growth continued for six to seven months and closely followed temperature patterns during this period. It is concluded that the growth of *N. solandri* is seasonal and that growth rings are annual.

KEYWORDS: *Nothofagus solandri*, phenology, seasonal growth, annual growth ring

INTRODUCTION

Tree growth in areas of seasonal climate is confined to periods of favourable conditions. Trees growing in mountain regions are strongly influenced by temperature with growth restricted to the warmer summer months (see review in Tranquillini 1979). Winter growth-dormancy allows trees to survive periods of unfavourable climate. The seasonal growth patterns of some New Zealand tree species, including *Nothofagus* species have been reported (P. Wardle 1963, 1971, Russell 1968, J. Wardle 1970, Wells 1972, Benecke and Havranek 1980, Palmer 1982). This paper investigates the seasonal pattern of shoot extension and diameter increment in *Nothofagus solandri* trees during two growing seasons in Sugarloaf Bush, Cass, Canterbury.

Location, biology and general features of Sugarloaf Bush are described by Burrows and Norton (1982) and some climatic aspects by Burrows *et al*. (1982). The results presented here form part of a wider study of *Nothofagus solandri* phenology.

METHODS

Four mature trees of similar height (12m - 14m tall) and single leader habit were selected from each of two forested sites. One site (site A) had a north aspect (NZMS1 S66 244173) and the other (site B) a northwest aspect (NZMS1 S66 245174). Topography, vegetation and altitude (ca. 800m) were similar for both sites.

Dendrometer bands were placed on all selected trees in August 1980 to measure diameter increment. The dendrometer bands consisted of stainless steel strips with a vernier scale (Liming 1957) with a resolution of 2.5×10^{-3} mm. Tension from a coiled spring held the bands permanently around the trees. One tree (from site B) was blown down during the study and could not be used in the results.

The shoots on five trees (three at site A and two at site B) were marked in August 1980 and measured during the subsequent two seasons. The junction on a branch of a prominent lateral shoot and the terminal shoot (approximately 10 cm to 20 cm from the terminal bud) was marked with paint. The shoot was then tagged to facilitate later identification. Only shoots exposed to full sunlight, at least for part of the day, were marked. The distances from the marked junction to the tips of both the terminal and lateral shoots were measured. 122 shoots (both terminal and lateral) were initially measured but several had to be discarded because of bud death and shoot breakage. 92 shoots (47 terminal and 45 lateral) are used in the final analysis.

Maximum-minimum thermometers which had been previously calibrated against one another were placed on one tree (at site A) at 1 m, 8 m and 12 m above the ground. The 8 m thermometer was removed after four months as records from it did not significantly differ from the others.

The dendrometers, shoots and thermometers were measured at approximately two weekly intervals over the summer and otherwise monthly, until June 1982. This time period spanned two growing seasons, 1980-1981 and 1981-1982.

RESULTS AND DISCUSSION

All growth data were converted from absolute values to cumulative percentages of total growth for each growing season. The results for diameter increment of six trees are presented in Fig. 1. One tree was excluded as it showed an apparent decrease in diameter increment, possibly because of incorrect dendrometer fitting. Diameter increment for both of the studied growing seasons started in November and ceased in June. All the trees exhibited a similar growth pattern. The combined data are presented in Fig. 3.

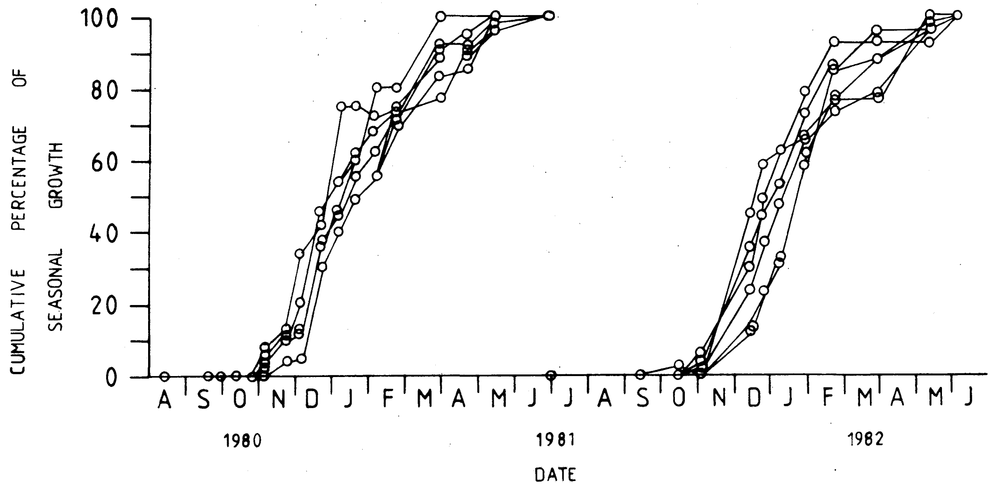

Fig. 1. Cumulative per cent of total annual diameter growth of six *Nothofagus solandri* trees through two growing seasons.

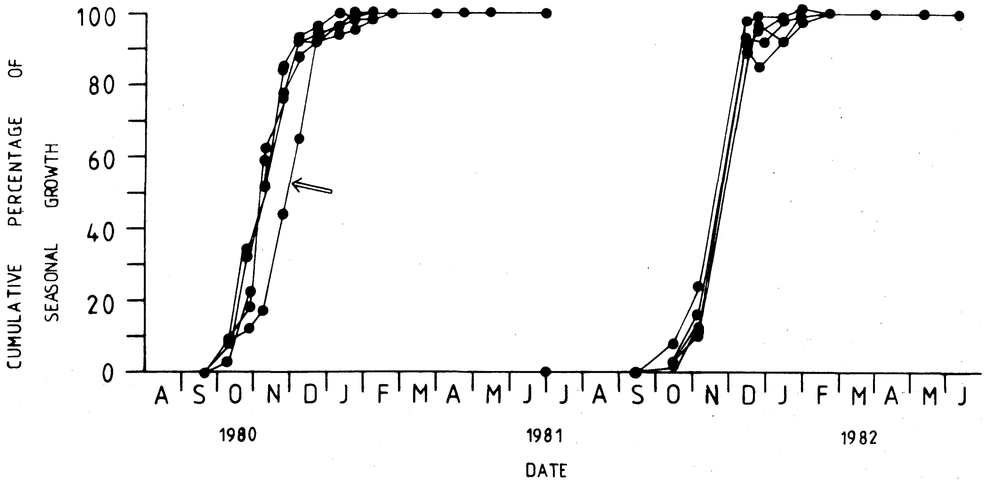

Fig. 2. Cumulative mean per cent of total annual shoot growth of five *Nothofagus solandri* trees through two growing seasons. The mean values and their standard deviations are given in Table 1.

TABLE 1. CUMULATIVE MEAN PER CENT (±1STANDARD DEVIATION) OF TOTAL SEASONAL SHOOT GROWTH OF FIVE *NOTHOFAGUS SOLANDRI* TREES FOR TWO GROWING SEASONS. DATA AS USED IN FIG. 2, n = NUMBER OF SHOOTS MEASURED. READINGS FOR LATE APRIL 1981, MAY 1981, JULY 1981, MARCH 1982, MAY 1982 AND JUNE 1982 ARE NOT INCLUDED AS CUMULATIVE GROWTH WAS 100% IN ALL TREES.

DATE	TREE 1 (n=8)	TREE 2 (n=14)	TREE 3 (n=26)	TREE 4 (n=7)	TREE 5 (n=37)
20.9.80	0	0	0	0	0
12.10.80	8±11	3±3	9±12	9±3	8±6
29.10.80	32±13	14±7	18±16	34±16	12±8
9.11.80	51±19	23±8	35±17	51±25	17±12
25.11.80	85±7	59±14	61±17	76±12	44±17
5.12.80	85±19	84±11	78±13	88±5	65±18
24.12.80	93±8	92±7	92±8	95±4	93±7
8.1.81	96±8	92±7	94±6	94±4	95±5
20.1.81	100±4	97±4	96±5	95±3	97±4
5.2.81	99±6	100±3	98±6	100±3	98±4
24.2.81	100	100±1	98±4	99±2	98±5
1.4.81	100	100	100	100	100
17.9.81	0	0	0	0	0
18.10.81	8±7	3±4	2±2	3±4	2±4
2.11.81	24±20	12±12	13±10	16±9	11±18
16.12.81	90±12	98±4	91±12	89±14	93±9
27.12.81	85±22	99±3	95±6	97±4	92±13
12.1.82	92±19	99±2	99±3	92±16	98±4
1.2.92	101±2	101±2	99±2	98±4	99±2
24.2.82	100	100	100	100	100

The results for shoot extension are presented in Fig. 2. Standard deviations for individual trees are given in Table 1. The pattern for all the trees was similar although shoot extension for one tree (arrowed in Fig. 2) was later in the first season but did not differ from the others in the second season. The combined data are also presented in Fig. 3. Shoot extension started in September in both seasons. 20% of total growth was completed by late October and 80% by mid December. Shoot extension commenced later in the second season. Despite this, however, growth ceased on a similar date in both seasons.

Temperature variations recorded by the three thermometers were very similar and the record from the 1 m thermometer is presented in Fig. 3. Small differences between the three thermometers were not significant and could be due to differences between the thermometers, notwithstanding the prior calibration. Maximum temperature rose above 20°C from November to March in both seasons and did not drop below 10°C all year. Minimum temperatures below 5°C occurred in most months and from May until the end of September, temperatures below 0°C occurred. Temperature variations in Sugarloaf Bush are discussed more fully by Burrows *et al.*(1982).

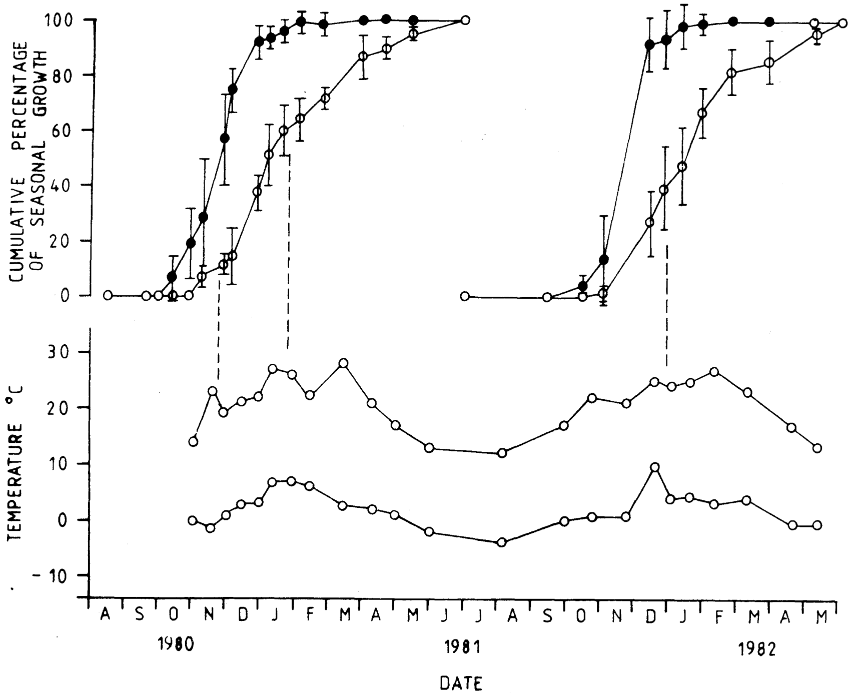

Fig. 3. Seasonal pattern of maximum (upper) and minimum (lower) temperature, and of cumulative mean per cent of total annual diameter growth (o) and cumulative mean per cent of total annual shoot growth (•) for two growing seasons in Sugarloaf Bush. Periods of reduced diameter growth associated with cooler temperatures are indicated by the dashed lines.

After bud break in September rapid shoot growth occurred; 90% of growth was completed within a three month period. Diameter growth occurred for a six to seven month period but did not commence until after shoot growth had started (Fig. 3). The period of tree growth approximates the period during which minimum temperatures were above $0^{\circ}C$ and maximum temperatures above $15^{\circ}C$. The rate of diameter growth closely followed temperatures, with reduced growth (indicated on Fig. 3) occurring during cold periods. Benecke and Havranek (1980) also observed this in *Nothofagus solandri* trees in the adjacent Craigieburn Range.

As leaves are shed in the season after they are produced (J. Wardle 1970), rapid shoot extension is important for *Nothofagus solandri* to ensure the production of sufficient photosynthetic tissue for the next season. Such a growth pattern enables *N. solandri* trees to complete shoot growth, even if the growing season is short. Diameter growth occurs after this and continues as long as conditions remain favourable. The curtailment of diameter growth appears temperature-dependent but summer soil moisture stress may also be important. No shoot or diameter growth occurred during the winter months.

The results obtained in this study agree with those obtained by J. Wardle (1970), P. Wardle (1971) and Benecke and Havranek (1980) from other *Nothofagus solandri* stands in the same area. Their studies were, however, confined to young trees and saplings and the results presented here extend phenological observations to mature trees. These earlier studies and the results presented in this study clearly show the seasonal nature of growth in *N. solandri* trees and confirm the annual nature of growth ring production.

ACKNOWLEDGEMENTS

A research grant from the Forest Research Institute of the New Zealand Forest Service is acknowledged. Colin Burrows and Jonathan Palmer are thanked for commenting on the draft manuscript.

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